7-8-2011

The Non-Infectious Disease Implications of Bed Bug Infestations

Christopher T. Balster
Wright State University - Main Campus

The Non-Infectious Disease Implications of Bed Bug Infestations

Christopher T. Balster

Wright State University

Table of Contents

Appendices

“He who has health has hope; and he who has hope has everything”

-Thomas Carlyle

Abstract

The purpose of this study was to determine the prevalence of bed bug infestations throughout Ohio, whether the non-infectious disease implications of infestations are public health concerns, and also determine the perceived ability of public health departments to respond to outbreaks within their jurisdiction. A descriptive study was performed using survey data obtained from 79 local public health departments throughout Ohio. Overall, 79.05% of individuals surveyed agreed that bed bug outbreaks are a public health concern. The mode of responses regarding whether or not the non-infectious disease concerns of infestations are a public health concern was 4 on a scale of 1 to 5, indicating that they agree that the non-infectious disease concerns are a public health issue. However, only 24.05% of health departments reported that their department was capable of managing bed bug complaints. Respondents indicated a general consensus that bed bugs and their non-infectious disease considerations are a public health concern, but sufficient resources are not available to curtail the problem. Consequently, this study suggests further emphasis be placed on the non-infectious disease ramifications of bed bug infestations as well as the continued use of Integrated Pest Management strategies to address the bed bug issue.

Introduction

Throughout the course of human history man has been plagued by an array of pests. Bed bugs, while considered to be little more than an obscure nuisance until recently, have had a significant resurgence around the world since the 1990s (Doggett & Russell, 2009). While infestations may fail to make headlines in many media outlets their presence comes with the potential of causing significant harm to the health and overall quality of life of those affected. There are several factors that have contributed to the increase in the pervasiveness of infestations in the world at large including the availability of rapid forms of transportation, insecticidal resistance, and improper hygiene practices (Reinhart et al., 2008). These factors have combined to make bed bugs a pertinent issue in the realm of public health. In order to fully grasp the magnitude of the problem these pests pose it is necessary to look at what kind of insects bed bugs are, the pervasiveness of infestations, what symptoms are associated with those living in infested dwellings, what is being done to treat these infestations, and potential problems in performing effective treatments. Lastly, while bed bugs have not been linked to direct disease transmission it may be more important to focus on the non-infectious disease aspects of bed bug infestations.

This study seeks to determine whether local public health departments view the non-infectious disease effects of bed bug infestations in a different light than they view the infestations in general. Therefore, my research question is as follows: do local public health departments view non-infectious disease implications to be a public health concern, and if so are they properly funded or capable of proactively treating the potential non-infectious disease aspects of bed bug infestations? The answers to these questions are not simple and can vary on a department to department basis making it vital to consider the existing literature before attempting to answer them.

Literature Review

History and Prevalence

The problems associated with bed bug infestations seem like they might describe a relatively recent public health problem, but, in reality, bed bugs have been observed for far longer than this observation would suggest. Bed bugs have been described in historical texts dating back to the writings of the ancient Greeks and Romans, some of the earliest Christian documents, and even in early American colonial literature, illustrating the continued presence of these insects throughout the world over millennia (Kolb, Needham, Neyman, & High, 2009). In fact bed bugs have been found and documented dating back to tombs in Tel al-Armana, Egypt from 3550 years ago (Delaunay et al., 2010). In the 20th century bed bug infestations were declining after 1950 due to the advent and application of pesticides such as DDT, but as a result of built-up resistances from environmental exposures as well as stringent insecticide regulations there has been a marked increase in infestations after 1990 (Kolb et al., 2009). Since 1980 there have been increased reports of bed bugs infesting homes, hotel rooms, hospitals, apartment buildings, and dormitories throughout the United States (Goddard & deShazo, 2009). The spread of bed bugs is not relegated to any one area of life, but can be taken to almost any locale.

Bed bug infestations have the potential to immensely impact the areas in which they occur. In Northern Kentucky a three-school district shut down all of their schools and sought to contact a professional exterminator when bed bugs were found on a middle school student's clothing (Krause-Parello & Scisione, 2009). In New York City there was an 866% increase in bed bug infestations reported in the year 2005 (Hurst & Humphreys, 2011). In 2004 there were only 192 reported bedbug cases in New York City, but by 2008 there were a total of 9,213

complaints spread throughout the 5 New York boroughs illustrating the capability of bed bugs to quickly propagate in this densely populated city (Hurst & Humphreys, 2011). In San Francisco bed bug infestations were doubled between the years of 2004 and 2006 (Goddard & deShazo, 2009). Hamilton County, Ohio, one of the first major Ohio counties to report bed bug complaints in the new millennium experienced a rapid increase in bed bug outbreaks during the past decade. In 2005 Hamilton County had 36 bed bug associated complaints but in 2008 the number of complaints soared to 305, again highlighting the ability for bed bugs to explode upon a population in a relatively short time span (Hurst & Humphreys, 2011). While bed bugs can infest virtually any type of residence some structures such as substandard housing can provide ripe breeding grounds for these parasites as a result of the potentially dilapidated state of the housing in addition to improper or inadequate precautions by the tenants and landlords.

The resurgence of bed bug infestations is not relegated solely to the United States, but can be observed throughout the world and in a wide variety of climates. Over a six month period in 2002 Toronto, Ontario, Canada experienced a 100% increase in the number of telephone reported bed bug complaints (Goddard & deShazo, 2009). A common belief about bed bugs is that they tend to disproportionately affect the less fortunate such as individuals who reside in homeless shelters, but over time there have been many studies that have come about to refute this notion (Goddard & deShazo, 2009). In 2003 a total of 46 locations were seen to be infected with bedbugs by Toronto Public Health with the most commonly hit dwellings being apartments (63%), shelters (15%), and rooming houses (11%) (Hwang et al., 2005). Pest control operators in the area surrounding and including Toronto were found to have treated infestations at 847 locations in the greater Toronto area during the year 2003 (Hwang et al., 2005). Of the 847 locations treated in 2003 70% were single-family dwellings, 18% were apartments, and 8%

shelters with the average shelter requiring $3,085 worth of treatment needed to eliminate their infestations (Hwang et al., 2005). The data gathered from the Hwang et al. (2005) study is important since citizens, as well as public health agencies, may fallaciously assume that bedbugs are a problem associated with a certain segment of the population and may cause them to overlook the true reality of the situation within their jurisdiction. An important point brought up in Hwang's 2005 article is that single-family dwellings are more inclined to contact pest control operators while homeless shelters tend to contact public health agencies, which may be a contributing factor to low complaint rates over the last decade.

Outside of North America on the isolated island continent of Australia a 4500% increase in infestations occurred between the years of 2000 and 2006 (Doggett & Russell, 2009). Throughout Germany there was a reported increase from 5 infestations in 1992 to a total of 76 cases reported in 2004 (Goddard & deShazo, 2009). Britain has observed comparable statistics since they reached a low of around 10 instances of infestation per 1 million people in the early 1960s (Reinhardt et al., 2009). The article regarding bed bugs in Britain noted the inability of many laypeople to properly identify bed bugs, which may ultimately lead to underestimation of the total burden during the years in which bed bug infestations were not as prevalent (Reinhardt et al., 2009).

One of the most dramatic cases of bed bug resurgence can be found in the African country of Nigeria. Of apartments surveyed in a Nigerian study only 16% were found to be completely bedbug free, while 62.2% of apartments were found to harbor egg cases and fecal marks, highlighting the pervasiveness of bed bugs in the rural Gbajimba in the Benue state of Nigeria (Omudu & Kuse, 2010). Even though there has been a significant increase in the number of bed bug infestations throughout the world in recent decades there has been little

attention paid to these parasites due to their apparent inability to result in severe clinical conditions. However, in order to understand how bed bugs are able to be so prevalent throughout the world it is beneficial to look at their physical characteristics in order to help explain their pervasiveness abroad.

Bed Bug Characteristics

Common bed bugs, *Cimex lectularius*, and tropical bed bugs, *Cimex hemipterus*, are obligate hematophagous parasites that prefer to feast on mammalian blood (Kolb et al., 2009). The life cycle of the bed bug is composed of five juvenile stages and an adult stage wherein the juvenile stage of development is characterized by having a light yellow coloration and a body length of around 1 mm (Doggett & Russell, 2009). Upon maturation an unfed adult bed bug is wingless, typically reddish brown and around 5mm in length (Goddard & deShazo, 2009). Once a bed bug takes a blood meal from a host the length of the bug may increase anywhere from 30% to 50% and its weight may increase by 150% to 200%, illustrating the relatively enormous amount of blood this parasite is capable of drawing in during a single blood meal (Goddard & deShazo, 2009). The capacity for the intake of large blood meals is relevant in that it allows bed bugs to pose indirect health consequences to victims of infestations and will be expounded upon in the health consequences segment.

Bed bugs are generally nocturnal, searching for hosts by actively sensing and seeking out warmth, which facilitates their ability to find warm-blooded animals (Goddard & deShazo, 2009). The average life span of a bed bug is between six months and a year, however, after blood meal bed bugs can survive upwards of one to two years without feeding, further reinforcing their image as a naturally hearty parasite (Goddard & deShazo, 2009). Bed bugs

have been shown to be resistant to a number of commonly used pesticides, including pyrethroids, making them a formidable nuisance when they infest a property (Romero, Potter, Potter, & Haynes, 2007). In addition to pesticide resistances bed bugs have displayed an extreme tolerance to heat fluctuations by surviving temperatures as cold as 7ºC and as hot as 45ºC (Kolb et al., 2009). This ability to withstand a relatively large amount of temperature variance would potentially make the ability to treat bed bugs using heating and cooling methods limited. These innate characteristics of bed bugs allow for the insects to infest dwellings for significant periods of time, and as a result, various clinical consequences can arise with the potential to significantly impact the lives of those infected.

Non-Infectious Disease Consequences

The ability of bed bugs to persist in an area, while troublesome, does not necessarily warrant alarm, however a closer look at the health consequences of bed bug infestations may help shed light on their true impact. A study conducted in Boston found that individuals who reside in public housing were found to have substantially higher rates of hypertension, high cholesterol, obesity, asthma, diabetes, and depression when compared to other Boston residents (Ruel et al., 2010). Not only has living in substandard housing been associated with the aforementioned maladies but it has also been shown to come with an increased risk of injury, poor nutrition, chronic disease, and poor mental health (Ruel et al., 2010). Reasons behind these maladies include being exposed to poor heat, inadequate ventilation, and dampness leading to mold and fungus growth (Ruel et al., 2010). These trends are important because pest infestations have been associated with chronic conditions, making the presence of bed bugs an issue worthy of note from a non-infectious disease perspective. In particular, pest infestations have been

found to exacerbate chronic diseases such as asthma, highlighting the ability of insects to affect those in substandard housing in unconventional ways (Krieger & Higgins, 2002).

Bed bugs have been written off in many circles as a result of their perceived inability to actively transmit diseases to their hosts, but the most significant effects of their infestations may occur outside of this area. Many times bed bug bites will go unnoticed due to a general lack of reaction to the bite (Hildreth, Burke, & Glass, 2009). When a reaction does occur it is frequently in the form of a minute-inflamed pruritic bump at the site of the bite, however, these bumps typically heal within two weeks of initial presentation (Hildreth et al., 2009). The presence of a weal at the site of a bite can be attributed to the dissemination of bed bug saliva, which is comprised of anticoagulants, vasodilator compounds, and proteolytic enzymes (Levy Bencheton et al., 2010). Treatment options for minor reactions usually involve the implementation of antihistamines and corticosteroids to reduce irritation around the affected areas (Doggett & Russell, 2009). In the event of an allergic reaction it is possible for the minor bump to become a more complex skin reaction known as an urticaria, which consists of inflammation and swelling of the skin around the location of the bite (Hildreth et al., 2009). In some cases the urticaria can turn into a bullous, a fluid-filled swelling, over the site and if itched can possibly result in secondary bacterial infections (Hildreth et al., 2009). In extreme cases asthma can occur alongside an infection, which may increase the likelihood of the individual developing urticaria or coming under a state of potentially fatal anaphylaxis (Hildreth et al., 2009). These consequences highlight the ability of simple bites to progress to potentially harmful developments.

Symptoms associated with bed bug bites are discernable for the most part, though there is still potential for clinicians to erroneously diagnose the bites and the resulting symptoms

associated with bed bugs as being something entirely different. For example bed bug bites have led to several reported misdiagnoses including scabies, antibiotic reactions, food allergies, spider bites, mosquito bites, Staphylococcus infections, hives, and chicken pox (Doggett & Russell, 2009). Subsequently, if a clinician does not suspect bed bugs to be the cause of the symptoms then it may not be difficult for the responsible physician to falsely diagnose their patient. In one case a patient who experienced anaphylaxis was misdiagnosed with a coronary occlusion, leading to a battery of unwarranted tests yielding inconsequential results (Doggett & Russell, 2009). As a result of misdiagnoses there have been instances in which health care providers have prescribed treatments such as scabicides, biopsies, and blood tests resulting in typically useless results and wasted money (Doggett & Russell, 2009).

An important and often overlooked issue relating to bed bugs is the potential impact on a victim's mental health. Bed bug infestations have historically been associated with a stigma that suggests that infestations are the result of poor hygiene and housekeeping, which has led to bedbug infestations becoming a very sensitive issue among many groups in society (Doggett & Russell, 2009). Along with the inherent stigma associated with bedbug infestations comes the potential for episodes of delusional paranoia by those infected where they imagine that bugs are crawling all over their bodies even after the infestation may have been eradicated for some time (Doggett & Russell, 2009). Other mental health effects associated with bed bug infestations include anxiety, episodes of insomnia, and a potential for the exacerbation of existing mental illnesses (Rossi, 2010). Bed bugs display a tendency to bite the neck and face of human hosts which results in bites and blemishes that have the potential to lower a victim's self esteem and also potentially hinder their performance at work or in attempting to acquire future work (Doggett & Russell, 2009). Eradications can cost up to thousands of dollars, and as a result they

can cause much stress and anxiety solely from the standpoint of coping with the cost of effective treatment options (Doggett & Russell, 2009). Thus, while the medical effects of bed bug bites can be serious there is significant evidence to argue that the effects of infestations on the mental health of affected tenants can be just as great if not greater.

Bed bug infestations can manifest in a multitude of physical ailments including the exacerbation of existing chronic conditions. In an extreme case a 60-year-old man presented with symptoms consistent with iron-deficiency anemia (Pritchard & Hwang, 2009). Prior to seeking treatment the man had noted bed bugs in his apartment up to two months before he started experiencing problems (Pritchard & Hwang, 2009). Following eradication of the bed bug infestation within his dwelling the man continued on treatments for iron-deficiency anemia and within 6 months that man's hemoglobin levels had gone from 52g/L during the peak of insect infestation to 157g/L following the eradication of the bed bug infestation (Pritchard & Hwang, 2009). This case illustrates the potential for severe bed bug infestations to cause severe medical issues when left unattended or in a situation where a tenant may not possess the knowledge and/or financial means to adequately address the issue at hand. The recent economic turmoil in the United States further amplifies the importance of being able to adequately finance effective treatment methods, making it something that might have to be looked at as a potential avenue for subsidization in extreme cases. It is important to note that the man mentioned in this case was a substance abuser and also had failed to have an adequate daily nutritional intake which both may have exacerbated his condition beyond that of what could be expected with a typically healthy individual (Pritchard & Hwang, 2009). The authors of this study point out that mentally handicapped individuals such as substance abusers, people with a mental illness, and other cognitive impairments may display more apathetic views toward infestations, thus allowing bed

bug populations to rise to extreme levels, which consequently can make them more prone to significant blood loss (Pritchard & Hwang, 2009). While bed bugs have the ability to exacerbate conditions such as iron-deficiency anemia they may prove to be conveyors of even more debilitating conditions with the potential to affect millions.

Recently it has become increasingly common to find individuals seeking to treat infestations individually, many times without seeking the counsel of professional pest eradicators. As a result there is the potential for a rise in the number of instances of overexposure to pesticide agents or even inappropriate applications of treatment techniques leading to serious health consequences. One instance, in particular occurred on January 21st, 2011 in Union Township, Ohio in which a victim of a bed bug infestation sought to treat his infested couch with a rubbing alcohol mixture in order to eradicate the bugs present on and within the couch (Geist-May, 2011). During this application of rubbing alcohol the resident, who was smoking a cigarette at the time, allowed for the cigarette ember to come into contact with the couch, resulting in the destruction of the couch and an adjacent area of carpet before the fire could be stymied in addition to severely burning himself in the process (Geist-May, 2011). This instance, and many more like it, occurs when tenants, landlords, or business owners attempt to treat ongoing infestations on their own without first consulting appropriate educational materials or contracting a professional to assess and mediate the situation. This case illustrates the severity of the problem associated with the non-infectious disease aspects of bed bug infestations by highlighting the dangers inherent in these infestations when a lack of information and precaution is involved.

The misuse of pesticides and other household chemicals have not gone unnoticed by oversight agencies. In Cincinnati during June 2010 an unlicensed pesticide applicator treated an

apartment complex with a pesticide typically used to treat golf courses, resulting in 7 tenants becoming sick, the property being quarantined, and eventually the forced relocation of all tenants (Leingang, 2010). In early 2010 the Environmental Protection Agency was cited as warning individuals affected by bed bug infestations to not apply pesticides designed for exterior use on the interior of their dwellings (Leingang, 2010). In July 2010 in Newark, New Jersey a pesticide company was accused of utilizing chemicals not approved for indoor use to treat 70 residences, going so far as to individually spray objects such as mattresses and children's toys (Leingang, 2010). The potential ramifications for actions such as these are immense and possibly lethal, but do not cover all of the problems brought on by ill-advised treatment techniques and unlicensed applicators.

Bedbugs and Infectious Diseases

There is a lack of evidence establishing bed bugs as vectors of human diseases, however, there are more than 40 illnesses that may be harbored by bed bugs including Trypanosomiasis, Leishmaniasis, yellow fever, hepatitis B, HIV and plague (Goddard & deShazo, 2009). In Latin America specifically bed bugs are suspected carriers and transmitters of diseases such as Trypanosomiasis which can create significant burdens to indigenous populations and transient tourists alike (Kolb et al., 2009). Recently studies have been undertaken to establish whether or not HIV and hepatitis B can be transmitted directly from infected bed bugs, however, while HIV infected blood was observed up to eight days after a blood meal bed bugs were not noted to have replicating HIV viruses in their stomachs or feces essentially eliminating them from the category of viable vectors of HIV (Goddard & deShazo, 2009). Also, wild bed bugs have not been found to harbor HIV, limiting their capability to serve as possible vectors for disease transmission (Delaunay et al., 2011). Hepatitis B has been investigated and is now considered as the most

likely illness to be transmitted by bed bugs since Hepatitis B surface antigens have been found within infected bed bugs up to seven weeks after they become infected but have not been seen to transmit the disease (Goddard & deShazo, 2009). While potential domestic disease transmission by bed bugs is a concern, worldwide infectious disease implications could dwarf this concern if bed bugs are found to be able to spread any number of infectious agents.

Trypanosoma cruzi, the causative agent of Chagas disease in South America, provides intriguing potential for disease transmission among bed bugs. In the wild Trypanosomiasis is transmitted by the triatoma bug, also known as the kissing bug, by being excreted in the feces of the bug during a blood meal (Delaunay et al., 2011). This is important because in many Latin American nations kissing bugs and bed bugs frequently cross paths, providing them ample time and opportunities to feed on the same hosts and cross-contaminate each other (Delaunay et al., 2011). Furthermore, bed bugs have been found to harbor *Trypanosoma cruzi* in the wild and have even been shown to be capable of ingesting the pathogen, allowing it to replicate inside their body, and passing viable parasites into their feces (Delaunay et al., 2011). Given the natural epidemiology of Chagas disease through the bite of the kissing bug it is not implausible that the disease would be able to proliferate in hosts after being bitten by infected bed bugs as well, which has made *Trypanosoma cruzi* a pathogen of interest for determining whether or not bed bugs can transmit disease (Delaunay et al., 2011).

A potentially frightening development has occurred where bed bugs been observed to harbor and excrete methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus faecium (VRE) (Lowe & Romney, 2011). Lowe and Romney (2011) showed that both MRSA and VRE were able to be cultured from infected bed bugs, implying that bed bugs may be able to pass these drug resistant pathogens between hosts as a result of the

ability of MRSA and VRE to enter human hosts by way of damaged skin, which is often a byproduct of bed bug bites. While bed bugs have not been definitively proven to directly transmit disease studies have begun illustrating that the potential for infectious disease transmittance is there, and perhaps the only thing holding it back is the ability to find a suitable pathogen to pass. In addition to the health ramifications for affected individuals it is also necessary to address the issue of how to treat infested dwellings if bed bug problems are to be truly alleviated.

Treatment Options

In an effort to eliminate bed bug problem homeowners and property owners are willing to use unproven techniques to treat bedbugs. In some instances affected individuals have even resorted to employing chemicals that can cause harm to the central nervous system, cause irritation to skin and other bodily surfaces, and in some instances have been shown to promote an increased incidence of cancer (Leingang, 2010). Incidents like what occurred in Union Township, Ohio beg the question of what can be done to mitigate infestations or prevent them from happening entirely. Some treatment techniques such as using hardware products like cedar oil, bug bombs, and other oils have been touted as cheap, effective methods of treatment for bed bugs, however, experts have stated that their ability to eradicate infestations is not as high as many believe (Leingang, 2010). In fact, the use of these alternative chemicals has been shown to disperse bed bugs instead of killing them, potentially leading to an increased burden for the homeowner or landlord affected (Leingang, 2010).

Ideally bed bug infestations are prevented before they ever have the chance of occurring, but given the imperfect nature of the world it is best to adopt a sound preventive program and to

properly treat the problem if and when it arises. In order to properly clear a bed bug infestation a series of steps are usually required. The steps to treat an infestation follow a simple pattern: identifying the species causing the infestation, educating those affected about the nature of the pest, determine the areas affected, thoroughly treating the infestation, and lastly following up on the eradication to determine if additional action is required (Goddard & deShazo, 2009). Properly performing this step-wise assessment and eradication strategy can give the persons involved a quality metric for how to respond in the event of an infestation, however, when faced with the dilemma brought on by a bed bug infestation it is important for those involved to understand the capabilities of all methods of treatment.

There are many treatment options for bed bug infestations, however, given the high cost and questions pertaining to the efficacy of some treatment options not all are accessible to the general public which raises ethical dilemmas especially in cases where those in government subsidized housing are affected. Types of treatment can come in both chemical and nonchemical forms. In the past when bed bugs reached their highest levels of prevalence in the 1920s and 1930s citizens did not have the luxury of novel, effective treatment methods, but after the advent of DDT and its liberal application to infected areas infestation rates began to significantly decline (Berg, 2010). After prolonged use of DDT as the main method of eradicating infestations bed bugs began to develop a resistance to the pesticide, which was then counteracted by the implementation of organophosphates such as diazinon and malathion to clear up residual infestations (Berg, 2010). As the years passed and organophosphates and other pesticides were linked to various detrimental health outcomes their use became restricted and in some cases forbidden in the United States (Berg, 2010).

Debates in Ohio have recently sprung up concerning the use of a carbamate pesticide known as propoxur to help curb the escalating number of infestations within Ohio's borders (Berg, 2010). The United States Environment Protection Agency currently forbids the use of propoxur in confines where children may be present due to possible carcinogenic risks posed by the pesticide (Berg, 2010). Propoxur was considered to be a temporary solution after a study conducted by Potter and colleagues at the University of Kentucky showed that propoxur and chlorpyrifos were used to treat bed bug populations that were shown to be resistant to pyrethroid treatments which are currently used to treat bedbug infestations (Berg, 2010). The study showed that the two older insecticides completely eradicated all of the resistant bed bugs within a day's time, which raised the question of whether or not propoxur could be applied to stymie bed bug infestations (Berg, 2010). Proponents of this plan pressed for Section 18 exemption for the chemical in the state of Ohio, but the United States Environmental Protection Agency denied the proposal citing past studies that showed the carcinogenic potential of propoxur even though there is a an amount listed within the Environmental Protection Agency's files that state that a dose of 0.004mg/kg/day would most likely not cause adverse health effects over the lifetime of any exposed (Berg, 2010). While propoxur does not represent a significant threat to the health of inhabitants in many cases if the pesticide was inappropriately applied there is a risk of overexposure and subsequent health ramifications.

Though chemicals have been employed for decades to treat pests ranging from potato bugs to bed bugs there has been an increase of resistances beginning shortly after the early treatment of crops and residences with DDT (Romero et al., 2007). A 2007 study regarding the role of insecticide resistance in the increase in bed bug infestations noted that resistance has been found in over 400 species of arthropods, consequently leading to the resurgence of various pests

as well as increased disease transmission (Romero et al., 2007). The problem of insecticide resistances is not solely a domestic issue and can be observed throughout the world. In Tanzania bed bugs were recently found to show heightened resistance to pyrethroids in areas where insecticide treated bed nets were employed in earnest (Kweka et al., 2009). Supplementing the inherent problems that arise with insecticide resistance bed bugs have been noted to be able to sense insecticide residues and have been shown to migrate away from areas treated with certain insecticides toward areas without treatment (Romero et al., 2009). There are not many alternative treatment options currently available to those affected by bed bug infestations. Insecticide resistances to pyrethroids such as deltamethrin coupled with restrictions on chemicals such as organophosphates, chlorinated hydrocarbons, and carbamate insecticides has severely limited the ability to curtail bed bug infestations and may inevitably lead to the continued escalation of this resurgent problem (Romero et al., 2007).

A major shortcoming of pesticide applications was exposed in a study conducted by Romero and colleagues in 2009. Bed bugs were placed in environments containing the insecticides chlorfenapyr and deltamethrin in situations where either no additional stimuli was present or where additional stimuli (heat, blood) were put in place (Romero et al., 2009). The scientists observed that the bed bugs would not avoid areas treated with chlorfenapyr, but avoided deltamethrin (Romero et al., 2009). When an additional stimuli was added in the form of a heat source and an area to take a blood meal bed bugs were seen to crawl over both types of insecticides to reach these stimuli, which highlights an inability to effectively deter the parasite from migrating to its host (Romero et al., 2009). When bed bugs were exposed to sub-lethal doses of deltamethrin they were found to exhibit increased patterns of activity which may pose a problem in containing infestations in areas treated by this agent (Romero et al., 2009). The fact

that a byproduct of treatment with deltamethrin is increased activity it could lead to the migration of bed bugs to distant areas as a result of surplus energy and activity. As a result of the apparent ability for bed bugs to avoid insecticide laden areas it is important that exterminators and property owners keep in mind factors such as how susceptible the bed bug population is, the presence of stimuli in the environment to cause bed bug movement, and the amount of insecticide coverage present in the affected area (Romero et al., 2009). By sensing the proximity of potentially fatal insecticides bed bugs may be able to harbor themselves in safe zones until the residual effects of the chemical agent wear off, allowing them to not only survive but eventually propagate. The aforementioned reasons and others like them have come to highlight some of the shortcomings associated with the use of insecticides as the primary form of treatment when dealing with bed bug infestations resulting in a search for nonchemical means of treatment.

Chemical measures have long served as the stalwarts for dealing with pest problems, but as resistances increase and costs for effective treatments rise affected individuals have begun to turn to alternative treatment methods to deal with problems associated with bed bugs. Nonchemical treatment options can vary from simple, preventative strategies to proactive treatment methods and behaviors that may be dramatically less expensive and more environmentally friendly than implementing insecticides within a living environment. In the event that a bed bug infestation is suspected it is important that tenants, staff, or landlords thoroughly inspect the suspected area in order to determine whether a bed bug infestation is present and also how comprehensive said infestation is (Kells, 2006a).

Thorough inspections may involve the disassembling of potentially infested furniture pieces along with subsequent relocation of said furnishings to appropriate areas to avoid the further spreading of the infestation (Kells, 2006a). Recently researchers have begun

investigating the ability of canines to detect bed bug infestations and locations through olfaction (Pfiester, Koehler, & Pereira, 2008). The dogs used in the study had a 97.5% positive identification rate and a 0% false positive rate (detection of bedbugs when not present) of bed bugs when tasked with determining whether they were smelling a bed bug or a specimen from several different insect species, which highlights the tremendous specificity by which canines can distinguish certain scents (Pfiester et al., 2008). Subsequently, dogs were able to discern live bed bugs and bed bug eggs from dead bed bugs, bed bug feces, and shed skins with a 95% positive identification rate and a 3% false positive rate (Pfiester et al., 2008). In addition to first inspecting for bugs, the utilization of a vacuum fitted with a collection bag during inspections is also advised because it allows for a quick, effective means of capturing bugs immediately after they are found and once complete the bag can be treated with diatomaceous earth, sealed, and thrown away (Kells, 2006b). While vacuuming during inspections or whenever one comes into contact with exposed bed bugs won't completely eliminate an infestation it will allow for the quick removal of bugs that may return to hiding spots if not captured (Kells, 2006b). Once detection has occurred the individuals affected have several home remedy options for treating their infested furniture and personal effects.

Bed bug infestations can cost significant amounts of time and money to adequately mitigate. However, some common household activities can be performed to rid items such as clothing of potential bed bug infestations (Naylor & Boase, 2010). A study conducted in the United Kingdom found that washing infested garments in water of at least 60ºC was able to effectively destroy all stages of the bed bug life cycle while washing at 40ºC was found to be effective against the active stages of the bed bugs but not their eggs (Naylor & Boase, 2010). Also, tumble drying clothing at a temperature of greater than 40ºC for a time period of at least 30

minutes, dry cleaning clothes with perchloroethylene, and reducing the temperature of clothing to -17ºC for 2 hours or more were found to be effective treatment methods (Naylor & Boase, 2010). In instances in which laundry apparatuses were not present it was found that simply soaking clothes in detergent-free water for 24 hours resulted in the mortality of bed bugs in the active stages of the life cycle, but failed to affect the eggs present within the clothing (Naylor & Boase, 2010). While placing infested clothing in the laundry may serve as a cheap and effective way to rid clothing of pests it may also lead to the spread of bed bug infestations throughout dry-cleaners and local Laundromats where the clothing of many others may be present (Naylor & Boase, 2010). While laundering clothes may prove effective at eradicating the bed bug infestation at the personal level it may be necessary to seek more comprehensive forms of treatment to properly exterminate the infestations in commercial or multi-unit structures.

Steam treatments have been shown to be highly effective methods of treatment for bed bugs when most conventional means (i.e. chemical treatments) are too dangerous or expensive to utilize, however, this form of treatment can become labor-intensive and cause a lot of undue stress when ensuring that it is carried out correctly (Kells, 2006b). For individuals who are attempting to personally treat their bed bug infestation with heat treatment it is imperative that they are mindful of several important suggestions including using a commercial unit, ensuring that the unit has a control for the amount of steam volume, utilizing an upholstery attachment to spread out the application area, and also to have a noncontact thermometer on hand to ensure that sufficient levels of heat are being reached to kill off the bed bugs (Kells, 2006b).

Isolating and treating infested areas with high temperatures has been shown to both inhibit the mobility of bed bugs and also to cause mortality at sufficiently high temperatures (Pereira, Koehler, Pfiester, & Walker, 2009). To effectively utilize heat treatment the affected

areas need to be cordoned off by something such as polystyrene sheathing boards in an effort to reduce the amount of heat required to warm the contaminated surfaces to adequate levels and to also insulate the areas to prevent heat loss (Pereira et al., 2009). Pereira et al. (2009) observed that bed bugs could withstand treatments up to 39ºC for up to 240 minutes without any mortality. As a result of the natural heartiness displayed by the bed bug it has been necessary to typically treat infested areas with temperatures around 44 to 45ºC in order to create a lethal environment for bed bugs. Not only can high temperatures cause lethality in bed bugs, but these levels of heat can also adversely affect bed bugs by decreasing their fitness and sometimes leading to delayed death, thus preventing the reproduction of bed bugs (Pereira et al., 2009).

As temperatures were increased from 41ºC to 49ºC the amount of time necessary to eradicate the entire bed bug population decreased (Pereira et al., 2009). Once the heat levels reach 41ºC bed bugs can become temporarily immobilized and after 100 minutes of exposure at this temperature 100% mortality was reached and at temperatures of 79ºC less than a minute was required (Pereira et al., 2009). Concerns that furniture and other structures exposed to this type of heating will be irrevocably damaged are also unfounded because the increases required to become lethal to bed bugs are most likely below those that would cause damage to furniture or other infested structures (Pereira et al., 2009). While heat treating bed bug infestations has proven efficacious there are several problems that may hinder a comprehensive implementation of this treatment method.

Heating an entire building to the point where bed bugs will die, purchasing the requisite equipment, providing for the energy requirements, and meeting the necessary treatment duration is extremely cost intensive and difficult (Pereira et al., 2009). Another form of heat treatment, volumetric heating, involves superheating an entire room to a temperature of around 140ºF and is

extremely expensive, typically costing around $50,000 dollars to adequately provide for a single pest control team (Berg, 2010). Given the inherent potential for heat treatments to cost large sums of money it is important to continue to entertain other alternative means of treatment when attempting to terminate an infestation.

Heating is not the only form of thermal treatment that has been shown to be efficacious of ridding environments of bed bug populations. If bed bugs can be isolated and placed into environments in which they cannot escape the potential for the implementation of cryogenic freezing of the populations is possible (Kells, 2006b). In order to freeze a bed bug population it would take holding an area to -5ºC for 5 days or more to ensure eradication of a bed bug population, however, if the temperature is decreased to a point near -26ºC (the supercooling point of the eggs) the amount of time required to adequately treat the infestation should markedly decrease (Kells, 2006b). Thermal treatments are effective methods of treatment when they can be afforded. However, given their propensity for being somewhat exorbitant in price it may be necessary for affected individuals to look for more cost-effective options (Kells, 2006b).

Areas that are likely to be the sites of chronic infections may be well served to use mattress covers to provide an additional barrier between the susceptible individual and any possible bed bugs taking up residency within the mattress (Kells, 2006b). If an infestation occurs it is possible for the owner of the cover to either dispose of the cover or treat the inside of the cover with an insecticide which would then serve as an insulator to keep the bed bugs in closer contact with the chemical agent while also providing a barrier between the agent and the person who sleeps on the mattress (Kells, 2006b). Diatomaceous earth can also be used to seal up cracks and other areas bed bugs may traverse by adhering to the outer shell of the bed bug and consequently leading to the excretion of bodily fluid by the bug until the insect eventually dries

up and dies (Berg, 2010). This method of treatment acts residually on both bed bugs that were directly affected by treatment as well as those who find their way back into the treated environment, but is slow to act and requires a fine dusting performed by a qualified applicator which are sometimes in short supply (Berg, 2010).

Certain progressive institutions such as hospitals have begun to create protocols for patients who may be exposed to bed bugs and may have brought them into the hospital. One such hospital, the Banner Good Samaritan Medical Center, has created a four pronged bed bug procedure (Hurst & Humphreys, 2011). The steps include identifying the pest, bring in environmental health services after discharge, isolating the room for a period of 72 hours, and if bed bugs are positively identified notifying the nurse supervisor of the possible bed bug exposure (Hurst & Humphreys, 2011). Upon completion of these initial steps the last step is to search for additional information if needed by going to their center's infection control site (Hurst & Humphrey's, 2011). This simple protocol provides a pragmatic if, then flow chart to ensure that potential bed bug infestations can be addressed and treated accordingly by using these standard guidelines. Given that a hospital already possesses numerous safety and infection protocols this procedure to treat bed bug patients would most likely be able to be folded seamlessly into their response protocols and may prove beneficial by providing a simple course of action in the event that bed bugs are found in any medical center to help limit the potential spread of bed bugs.

Integrated Pest Management

Currently the utilization of an integrated pest management (IPM) process is advised when dealing with bed bug infestations (CDC). This approach involves implementing the most up to date information in order to better understand the life cycle of the organism of interest along with

its interaction with the hosts and environments which they come into contact with during a typical life cycle (CDC). When sufficient information has been gathered responders can decide which form of treatment is most suitable for that specific situation allowing for a more cost effective treatment process to be undertaken by tailoring it to the specific environment (CDC). As such the IPM process utilizes a variety of monitoring and treatment procedures including the utilization of monitoring devices, removing and limiting clutter whenever possible, heat treating, vacuuming, sealing cracks, applying nonchemical pesticides (diatomaceous earth), and applying chemical pesticides sparingly (CDC).

Public Health's Ability to Intervene

As the methods for treating infestations evolve to incorporate the most recent findings and technologies it is important to note the existing limitations that exist in the realm of the management of these pests both domestically and abroad. In order to assess public health's capability to react to outbreaks it is important to look at the history of public health as a whole to discern the shortcomings present in outbreak mitigation. One of the major impediments surrounding effectively mitigating bed bug infestations may lie in public health's gradual transition from social reform to the ability to treat disease outbreaks after they occur (Fairchild et al., 2010).

The advent of public health's mission occurred around the middle of the 19th century, where physicians, chemists, civil engineers, and other supporters of social reform sought to bring about changes in areas such as urbanization and industrialization (Fairchild et al., 2010). The aim of this reform was to cut down on the perceived causes of many of the maladies and illnesses that afflicted the public at this point in American history. During this period of history America

was fraught with epidemic diseases including small pox, cholera, and yellow fever, which were at the time attributed to the mass influx of immigrants and the amount of poor residing in America (Fairchild et al., 2010). Consequently, social changes in the arenas of housing and industry impacted previously affected citizens by regulating their environmental exposures to hazardous surroundings and as a result the death rates and overall amounts of pestilence began to subside throughout America (Fairchild et al., 2010). By fundamentally changing the environment in which people lived it was possible to limit their interactions with harmful pathogens and chemicals. Furthermore, by standardizing housing and plumbing codes it did not allow for major deficiencies to be present among any level of society, thus allowing for most individuals to limit harmful exposures (Fairchild et al., 2010). In the aftermath of events such as the Triangle Shirtwaist Company fire in 1911 further reform was sought in the area of occupational health, leading to improved working conditions for countless members of the working class (Fairchild et al., 2010). While major strides in urban development and occupational safety were made throughout the 19th the century and into the 20th century in urban these improvements inadvertently led to a transition from pervasive infectious disease problems to issues dealing with chronic illnesses (Fairchild et al., 2010).

As time passed public health transitioned from an entity that was firmly involved in the departments of sanitation, hospital care, and housing to an extension of local government that, in 1940, sought to focus on performing six basic tasks to attempt to maintain the public's health (Fairchild et al.,2010). The "basic 6" was composed of collecting data on vital statistics, controlling communicable diseases by observing and monitoring outbreaks, contact tracing, partner notification, isolation, and quarantine (Fairchild et al., 2010). Evident in the big six tasks is the departure of local public health from housing programs and sanitation to the more modern

tasks associated with curtailing major disease outbreaks. Whereas public health and medicine were very much intertwined during the infancy of public health as the Cold War approached public health found itself replaced by the medical community as the agency responsible for the health of the public while other areas that were once governed by health departments including trash collection and air pollution control were placed under the responsibility of various other government agencies and professions (Fairchild et al., 2010). The result of this dispersion of tasks and responsibilities was that public health had lost much of its power both in the political and medical arenas.

As scientific processes became more and more complex public health found itself deferring to the scientific community in most respects. The lack of political power made public health reticent in attempting to overcome stances of some major corporations, entrenched moral ideals, and gender disparities relating to class, gender, and race (Fairchild et al., 2010). Public health relies on science and research to highlight the most pressing health matters. For instance, when a novel pathogen is isolated and is responsible for severe morbidity or mortality scientific data can back up beliefs concerning that pathogen as a public health concern. Once a risk is ascertained public health authorities can then attempt to intervene and take steps to reduce transmission pathways or limit potential sources of contagion. Therein lays the problem when dealing with the recent bed bug outbreaks. Bed bugs have yet to be shown to be efficient vectors for disease, and as such are not deemed by many scientific authorities as threats of causing significant morbidity among the population (Goddard & deShazo, 2009).

Public health has seen its ability to directly address the bed bug issue atrophy as a result of budget cuts, removal of housing programs, and disparate overall mission statements (Eddy & Jones, 2011). As these issues generally relate to policy there augmentation can be suggested at

this time but any reasonable change should not be expected in the near future unless bed bugs become synonymous with efficient disease transmission. It is therefore important that public health agencies look at factors that may be contributing to the somewhat sudden re-emergence of infestations throughout the world in an effort to reduce the spread of these parasites while also developing a more comprehensive surveillance system.

Local public health departments possess minimal resources to combat bed bugs especially in light of other pressing issues such as disease transmission and pregnancies among teens (Rossi, 2010). Another possible hindrance in addressing this issue is ambiguity present in housing regulations and municipal codes that do not clearly state which parties are responsible for procuring appropriate treatment for ongoing infestations (Rossi, 2010). As a result of this problem tenants and landlords have a propensity to struggle over placing blame on the appropriate party due to the potential high costs associated with effective treatment methods (Rossi, 2010). Other issues for affected individuals involve trying to control outbreaks in multi-family homes where the potential for bed bugs to spread is much more likely than single family dwellings given the ability for bed bugs to be transported by humans and to move through the walls of complexes (Rossi, 2010). Lastly, the increase of insecticide resistant strains of bed bugs continues to be a pressing concern especially since it severely limits viable treatment options in many cases (Rossi, 2010). In response to many of these limitations communities stricken with these problems have begun to attempt to initiate plans aimed at alleviating the effects of pervasive infestations.

Bed bug infestations are community-spanning ordeals that require the cooperation of both the owners and tenants of a property and the public health entities present within said community. As of 2010 several community initiatives have been enacted to promote more

effective means of treating bed bug outbreaks. One form of community involvement concerns the passing of local legislation in an effort to clearly identify who is responsible for procuring adequate pest control among the potential landlords and tenants involved (Rossi, 2010). Another form of action involves the production of a comprehensive information network that will inform the public of the issues at hand and allow for those affected to be exposed to proper means of identification and outlets to contact in the event that an infestation has arisen (Rossi, 2010). By promoting improved communication and increasing the knowledge of the lay public it is possible that public health authorities may be able to significantly stymie the spread of these pests and slow the resurgence of this insect. Lastly, as mentioned before alternative methods of treatment and detection, such as the use of dogs, can be incorporated to reduce the overall cost of treatment and potentially improve the ultimate outcome of an outbreak (Rossi, 2010).

Future outbreaks may ultimately require the state or federal government to intercede and provide assistance in the form of creating novel information avenues, creating an interagency taskforce aimed at addressing the shortcomings of current research, or funding the development of advanced, cost-effective treatment techniques (Rossi, 2010). While many infestations may be able to be treated adequately using conventional chemicals there remains the issue of environmental exposures to those who dwell inside the residence after the application takes place. In many instances less fortunate individuals tend to be disproportionately affected and this notion reflects the principle of environmental injustice whereby the poor and minority populations have a propensity to be exposed to excessive environmental hazards (Rauh, Landrigan, & Claudio, 2008). The resurgence of the bed bug throughout the world has led to the question of what is the ideal method for dealing with infested areas. Answering this question requires the ability to appraise existing data relating to the efficacy of treatment options, both

chemical and nonchemical, as well as housing protocols and monetary factors in an effort to come up with the most suitable treatment option for the infestation at hand. Successfully implementing an integrated pest management program, coupled with improved communication regarding detection and treatment options for bed bugs to individuals who may be affected holds promise for helping to reduce the burden of bed bug infestations worldwide.

The history and prevalence of bed bugs, along with the potential ramifications of infestations and the subsequent treatment methods used to curtail infestations have led to the formation of a research question that seeks to determine the beliefs of local public health officials in regard to this re-emerging problem. Do local public health departments view the non-infectious disease implications of bed bug infestations to be a concern and, if so, do they believe that it is the responsibility of local health departments to address the issue if it presents itself in their jurisdiction?

Methods

Design

A phone based interview was conducted to determine the number of bed bug related complaints throughout Ohio, how bed bugs are viewed by local public health departments, and whether or not the non-infectious disease concerns make bed bug infestations more of a public health concern than previously thought. Analysis of the scientific literature, applied research, and various agency documents was conducted to deduce whether or not bed bugs are being given attention by local public health authorities and whether or not said authorities possess the ability to be proactive in the mediation of bed bug outbreaks throughout the state of Ohio. The Institutional Review Board at Wright State University reviewed and approved this study before data collection commenced (See Appendix A).

Sample/Setting

The state of Ohio was picked to be the setting for a case study investigating the beliefs of public health professionals regarding the concerns brought about by bed bug infestations as well as the number of complaints received in recent years. Ohio was chosen as the setting for the study for two primary reasons. The first reason behind choosing Ohio as the setting is that the principal investigator resides in Ohio making the reactions of Ohio authorities of great personal interest. The second reason behind choosing Ohio as a setting lies in the fact that Ohio has been mentioned in many pieces of literature and media as one of the most affected states in the country (Eddy & Jones, 2011).

An extensive literature search was conducted to shed light on the history of bed bugs throughout the world, their re-emergence in the world and the United State in particular, the health consequences of their infestations, and the current treatment methods for ongoing infestations. The literature review consisted of documents found in scientific journals, government organizational websites, and various news outlets. The information found from these sources was used to characterize the burden posed by bed bug outbreaks in the United States and abroad. Given the recent outbreaks in Ohio there were ample articles from news outlets detailing businesses and residences affected by bed bugs, allowing for the connection of this study to ongoing events.

A brief questionnaire was formulated to cover topics such as whether or not bed bug infestations were a public health concern, whether or not the non-infectious disease implications of bed bug infestations warrant concern, and what treatment methods or strategies are preferred among local public health departments. Two of the questions created were created to determine

whether or not departments felt like they were funded and/or provided with adequate resources to respond to bed bug complaints as they arose. These questions were created in order to gather information directly from environmental health professionals in departments throughout the state of Ohio.

The pool for potential participants was gathered from the Ohio Department of Health's website (http://www.odh.ohio.gov/localhealthdistricts/localhealthdistricts.aspx). The Ohio Department of Health website contains detailed information on every local public health department in the state including location, population overseen, and contact information for various members including the environmental health directors. Since pest infestations fall under the jurisdiction of environmental health departments the directors of said departments were compiled along with pertinent contact information. Each of the 88 major county health departments was included in the list as well as 7 of the largest city health departments throughout the state to allow for a broad enough range of participants to be contacted. All entries were entered into a Microsoft Excel spreadsheet to allow for easier organization.

Data Collection

Phone calls were made to 95 health district/departments within the state of Ohio from information gathered from the Ohio Department of Health's website. Communication was established with local health departments by directly calling each department from the compiled list and asking for the listed environmental health director by name. If the environmental health director was unreachable someone who oversaw nuisance complaints was then asked for. Once communication was established the principal investigator read a prompt detailing the purpose of the study, the voluntary nature of answering the questions, the anonymity of responses, the risks

posed by the study, and the potential benefits from participating (Appendix A). At the conclusion of the introductory prompt and at the request of the Wright State University Institutional Review Board participants were asked if they desired the contact information for the principal investigator or the IRB if they had questions regarding the research or research in general. When individuals were unable to be contacted the corresponding health department was marked accordingly and was called back once all subsequent calls had been made. Of the 95 health districts/departments targeted in this study 79 were able to be reached and agreed to participate in the survey representing an 83.16% response rate to the survey. Individuals who were unable to be reached directly after a minimum of two attempts were left a voicemail detailing the identity of the principal investigator and pertinent background information for the survey including length and estimated time required for completion.

Individuals who were able to be reached were apprised of the scope of the research, the voluntary nature of the survey, the risks of the survey, and ensured that they would remain anonymous. After being read these parameters participants could either choose to provide consent or decline to participate as desired. No individuals refused to participate, however, several required subsequent call backs to complete the survey as a result of having prior obligations. The responses to the survey questions, which were received over the phone by the principal investigator, were typed on into a Microsoft Excel spreadsheet with no discernable identifiers attached to the department other than the region of Ohio in which the department resides. Once completed the files were saved onto a hard drive and printed to hard copy.

Data Analysis

Following the telephone questionnaire, the compiled data was subjected to analysis in order to determine what trends, if any, existed within. This paper finds that the 79 people who were able to be reached for interview provided sufficient for data analysis. For the yes or no questions, responses were compiled to determine the percentage of respondents who responded yes or no to each. For question #2 which referred to the first reported bed bug complaint and subsequent questions about rates in 2010 and demographic characteristics of those most affected the mode and median for the year of incidence was first obtained followed by creating a range for complaints received in 2010. Five respondents indicated that they had not experienced an initial bed bug complaint and were subsequently not factored into the mode and median calculations relating to incidence. Modes were obtained to show which year was most often the beginning for bed bug complaints in a given area. As a result of part b of question #2 not reflecting concrete numbers a range depicting the amount of bed bug complaints observed was created for each region and overall to illustrate which areas not only had the lowest and highest number, but also which possessed the most variance in complaint numbers. The demographic characteristics found in the survey were then compiled into a table in order to illustrate the number of responses reflecting each type of population mentioned.

The remaining modes were calculated for each question using the same method used for question #2. The mode for each Likert type question was calculated individually prior to combining response data with companion questions in order to observe any shifts in response trends of individual responses vs. grouped responses. In order to compare questions #3 and #4, which dealt with whether or not bed bugs were a public health concern and if their non-infectious disease implications were reasons for concern, the responses to question #3 were reverse coded

to mirror responses obtained from question #4 and subsequently grouped together. As a result, for individuals who agreed that bed bug outbreaks are a public health concern rather than just a nuisance and also that the infestations have disease implications that make them a public concern worthy of note a corresponding number of 4 or 5 would be found. Modes for questions #7 and #8 were calculated and compared since they were related to funding and treatment options to determine what trends, if any, were present when modes were found for individual answers compared to grouped replies.

Once the data was tabulated the analysis for each question was redone by area of Ohio by breaking the responses down into geographical areas of northeast, northwest, southeast, and southwest to determine whether or not unique trends emerged. A graphical representation was not created for each geographical area at the discretion of the principle investigator. Upon completion a final evaluation of the data was made along with recommendations on potential courses of action consistent with information obtained during the literature review.

Results

The survey questions utilized in this study sought to determine the answer to questions such as whether or not bed bug infestations were viewed as a public health concern in Ohio, when infestations were first reported in each jurisdiction, how many complaints were received in 2010, and whether or not respondents believed that their public health department was capable of managing bed bug complaints. Overall, 80.38% of participants responded that they believed bed bug outbreaks were a public health concern (Table 1). Of the four Ohio regions the northeast region was observed to respond that bed bugs are a public health concern 89.47% of the time, the

southeast region had the second highest affirmative response rate with 86.84% followed by the northwest with 78.26% and southwest with 66.67%.

Question #2 was broken down into two parts, the first depicting the mode of the year of the first bed bug complaint and the second depicting the range of complaints in 2010. Overall, the mode for initial year of bed bug complaints was found to be 2010 throughout all of Ohio. The mode for the initial year of onset for the northeast was 2010. The median year for initial complaint for the northeast region was 2009 and the range of years for first complaints spanned 17 years (1994-2011). The mode for the northwest was 2010, the median year for the northwest was 2010 and the range of years of initial complaints was 4 years (2007-2011). The mode year for the first year of complaints for the southeast was 2009, the median year for the southeast was 2009 and the range of years for the initial complaints was found to be 5 years (2006-2011). The southwest was found to have a mode for initial complaint of 2010, a median of 2008 and a range of 8 years (2002-2010).

Table 1

Question n = sample size	Northeast n = 19	Northwest n = 23	Southeast n = 18	Southwest n = 18	Total n = 79
#1	89.47%	78.26%	86.84%	66.67%	79.05%
#2a	2010	2010	2009	2010	2010
#2b	0 to 100	0 to 20	0 to 75	0 to 365	0 to 365
#3	2	2	1	1	2
#4	5	4	4	3, 4, 5	4
#3 and #4	4	3	4	1, 2, 3	4

The range describing the number of bed bug complaints received in 2010 was 0 to 365 overall. The widest range present among region was 0 to 365 in the southwest, followed by 0 to 100 in the northeast, 0 to 75 in the southeast, and 0 to 20 complaints in the northwest. In response to question #2c there were 27 health departments able to identify specific populations

more at risk than others. The 27 health departments able to identify groups more likely to be affected mentioned a total of 5 different sources of complaints (See Table 2).

Forty-nine of the health departments stated that bed bug complaints affected groups of people sporadically or they had not yet received a bed bug complaint. Lodging Establishments (hotels and motels) were mentioned in 3 cases, apartments and other multi-unit rental properties were mentioned 11 times, low socioeconomic status was mentioned 14 times, and younger people and tourists were mentioned once a piece.

Table 2
Complaint Demographics

Apartment/Multi-unit/Rental	11
Lodging Establishment	3
Low Socioeconomic Status	14
No Specific Populations	49
Tourist	1
Younger People	1

The third question pertained to whether or not the lack of an ability to transmit disease lessened the threat posed by bed bugs by making them more of a nuisance than a pressing public health concern. The question was reverse coded so that an answer closer to one coincides with agreeing that bed bugs are more of a nuisance than a public health concern while a score closer to five implies that bed bugs are still a public health concern and not just a nuisance. The overall mode of participant's responses was a 2 (median of 2 and a range of 1 to 5) on a Likert scale of 1 to 5. Of the different Ohio regions the southeast and southwest had the lowest modes with a 1 (2, 1 to 4) and 1 (1.5, 1 to 5), followed by the northwest region with a mode of 2 (2, 1 to 4) and the northeast region with a mode of 2 (2, 1 to 4). Question #4 focused on whether or not the non-infectious disease effects that sometimes result from bed bug infestations are a public health concern. The mode response for this question was 4 (4, 1 to 5) overall. The northeast had a mode of 5 (4, 3 to 5), the northwest a mode of 4 (4, 1 to 5), the southeast a mode of 4 (4, 1 to 5), and the southwest followed with a trimodal response pattern of 3, 4, 5 (4, 1 to 5). When

questions #3 and #4 were combined they were found to have an overall mode of 4. The northeast region had a combined mode of 4, the northwest had a combined mode of 2, the southeast had a combined mode of 4, and the southwest was trimodal with the 1, 2, and 3 answers receiving equal numbers of responses.

Questions #5 and #6 related to the ability of health departments to manage bed bug complaints and also whether or not local public health departments possessed the resources to effectively combat bed bug infestations (Table 3). When asked if their specific department was capable of managing bed bug complaints the overall response was 24.05% of participants stating that their department is capable of managing bed bug complaints. The region with the highest affirmative answer percentage was the northwest with a 39.13% yes response rate. The second highest percentage was from the southwest region with 22.22%, followed by the southeast with 21.05%, and the northeast region which had 10.53% of respondents who stated that their department is adequately funded to manage bed bug complaints. Question #6 detailed whether or not respondents believed that local public health departments were properly funded to respond to bed bug complaints. The overall mode for question #6 was 5 (median of 5, range of 2 to 5). The northeast region's mode was found to be 5 (5, 2 to 5), the northwest's was 5 (5, 3 to 5), the southeast's was 5 (5, 4 to 5), and the southwest's was found to be 5 (5, 4 to 5).

Table 3

Question **n = sample size**	Northeast n = 19	Northwest n = 23	Southeast n = 19	Southwest n = 18	Total n = 79
#5	10.53%	39.13%	21.05%	22.22%	24.05%
#6	5	5	5	5	5

Question #7 asked how strongly respondents agreed with the notion that educating the public about preventative measures is one of the best methods for combating bed bug infestations

(Table 4). The overall mode for all responding health departments was a 5 (median of 5, range of 2 to 5) on a Likert scale from 1 to 5. The northeast region exhibited a mode of 5 (5, 4 to 5). The northwest region had a mode of 5 (5, 3 to 5). The southeast region had a mode of 5 (5, 2 to 5) and the southwest region was found to have a mode of 5 (5, 2 to 5). Question #8 asked how important it was for the creation of a new pesticide to combat bed bug infestations. The overall response mode was 5 (median of 4, range from 1 to 5) among all regions. The highest regional mode was the southwest with 5 (5, 3 to 5). The second highest region was the southeast with a mode of 5 (4.5, 2 to 5). The northeast region displayed a bimodal response rate with modes of 3 and 5 (4, 1 to 5). Lastly the northwest region had a mode of 4 (4, 1 to 5). When questions #7 and #8 were combined all the observed modes were calculated to be 5, or strongly agreeing with the survey questions they correspond to.

Table 4

Question **n = sample size**	Northeast n = 19	Northwest n = 23	Southeast n = 19	Southwest n = 18	Total n = 79
#7	5	5	5	5	5
#8	3, 5	5	5	5	5
#7 and #8	5	5	5	5	5

Discussion

The results obtained from surveying seventy-nine of Ohio's local public health departments corroborate much of the previously established research regarding bed bug infestations and ways to treat said infestations (Eddy & Jones, 2011). Overall, 79.05% of health departments were found to consider bed bug outbreaks to be a public health concern. This percentage would appear to indicate that a majority of environmental health professionals in Ohio believe that bed bugs do pose at least some threat to the public's health. The 22.80%

disparity found between the highest and lowest responding regions, northeast (89.47%) and southwest (66.67%), was larger than expected, but is not overly surprising given the limited sample size and the fact that question #1 could be interpreted in a variety of ways depending on the views of the participant. The first question could be interpreted in many ways including whether or not bed bugs can affect the health of individuals who have infested dwellings to whether or not the housing codes and legislation state that bed bug outbreaks fall under the guidelines of the public health department in question to manage. The large overall number of affirmative responses (62.5), with one respondent answering both yes and no, illustrates that many public health practitioners view bed bug infestations to be a problem worthy of notice in the realm of public health. These results were expected as a result of literature illustrating effects such as the clinical consequences of bed bug bites as well as the non-infectious consequences of infestations (Ruel et al., 2010).

The years of initial complaints throughout the state varied from 1994 to 2011. Interestingly the region with the lowest initial complaint was the northeast region with a year of onset dating back to 1994. This is interesting as a result of the belief that the southwestern region of Ohio was thought to be the area in which bed bug outbreaks initially started appearing throughout the state before they began to radiate to different areas (Hurst and Humphreys, 2011). However, even though bed bug outbreaks have been reported to be more prevalent in the southwestern region of the state it is not unfeasible that outbreaks could have still been reported or experienced in other areas at an earlier time than previously thought. Also, the lack of specificity required to answer this question does not narrow down the initial reports to exact months, making this generalization important but not overly descriptive.

The ranges of complaints received in 2010 varied between 0 to 20 complaints in the northwest region to between 0 to 365 complaints in the southwest region of Ohio. The number of complaints shows that the southwest region does in fact possess areas with the highest volume of bed bug related complaints in Ohio as is to be expected from various pieces of literature referring to Cincinnati and southwest Ohio as hotspots for bed bug infestations (Eddy & Jones, 2011). Furthermore, the fact that the northwest and southeast regions have fairly low numbers might reflect the fact that many of the counties and cities in these areas are either not as densely populated or more rural in nature than the areas present in the southwest and northeast regions. However, it is important to note that these ranges may not reflect the true pervasiveness of bed bug infestations throughout the state since not everyone contacts health departments to seek advice or report infestations. Furthermore, establishments such as hotels are under the jurisdiction of the state fire marshal and may therefore report to that agency, thus diluting the true numbers of infestations and subsequent complaints in affected areas. The demographic characteristics noted in the survey are all consistent with groups listed in the literature as more susceptible to infestations than others (Hwang et al., 2005). The lack of a significant number of demographic responses makes it hard to discern any specific patterns of infestation. Infestations, therefore, may or may not be the result of insufficient reporting or the ability of bed bugs to infest any area of society, thus making everyone more or less equally susceptible.

The fact that bed bugs have not been found to be capable of direct disease transmission is something that has allowed for their trivialization as pests in some circles (Eddy & Jones, 2011). The third survey question sought to see if this fact made bed bug outbreaks more of a nuisance than a true concern. The mode for this question was 2 out of 5 (26 of 79 responses), indicating a score trending towards disagreeing with beds bugs being a public health concern and rather

viewing them as a nuisance. The second most frequent response was a 1 (25 of 79 response) indicating a strong disagreement with the statement that bed bugs are more of a public health concern than a nuisance. Bed bugs are by all means a nuisance, but their lack of an ability to directly transmit disease efficiently obviously makes them seem like less of a threat to public health than other vectors of disease. As such, bed bugs are sometimes viewed as no more than a pest that is hard to kill and can persist for long periods of time if not adequately treated. The mode for responses as to whether or not the non-infectious disease implications of bed bug infestations are a public health concern was 4 (28 of 79 response) overall. This mode indicates that public health professionals most frequently noted this aspect of bed bug infestations to be of importance to public health. The second most frequent response was a 5, or strongly agreeing that the non-infectious disease aspects of bed bug infestations are a public health concern (27 of 79). When questions #3 and #4 were combined to determine which responses outweighed the others an overall mode of 4 (54 of 158 responses) was observed, which would seem to imply that public health officials are leaning toward bed bugs being a public health concern especially in regard to the non-infectious disease ramifications of their infestations. While the threat posed by bed bugs seemed to be well understood the questions pertaining to funding proved to reaffirm previous beliefs (Eddy & Jones, 2011).

The 79 health departments surveyed produced a 24.05% “yes” response rate to whether or not bed bug outbreaks are capable of being managed by their respective departments. This statistic is consistent with literature that states that most local health departments do not possess the means to address infestations when they occur within their jurisdiction (Eddy & Jones, 2011). It is important to note that the “yes” response rate may in fact be lower and that many of the departments that answered “yes” did so with the caveat that they do not actively go out to treat

bed bug infestations but rather provide affected individuals with information pertaining to treatment options as well as to future preventative strategies. Question #6 supported the results of question #5 by showing that public health officials agreed, overall mode of 5 (55 of 79 responses), with the statement that local public health departments do not possess sufficient funds and/or resources to combat bed bug infestations.

Participants provided mixed responses to question #7 which asked if public health officials agreed with a statement that suggested that one of the best ways to combat bed bug infestations is to educate the public about preventative measures. The overall mode score for question #7 was 5 (49 of 79 responses), but there were 6 instances in which respondents noted that education does little good if those you educate are apathetic to the advice they are given. While providing information does enable individuals to utilize preventative strategies, if nothing is done to implement strategies and ideas then infestations may continue to occur regardless. The overall mode observed with question #8, which asked respondents to agree or disagree with a statement saying that a new pesticide is necessary to combat bed bug infestations, was also 5 (39 of 78 responses), indicating that public health practitioners most frequently strongly agreed that the creation of a new pesticide is necessary to effectively mitigate the correct increase in bed bug numbers. When participants varied on this question it was largely due to the fact that insecticide resistances are an inherent problem when treating bed bugs and that any new pesticide is likely to become inefficient over time. Combining questions #7 and #8 provided an overall mode of 5 (88 of 157 responses) as well, indicating that public health officials strongly agree that education and chemical measures are both necessary to provide adequate treatment options to the public in the future.

Though this study was able to obtain a large sample size from the targeted population (79 of 95 possible) there remain several limitations inherent to this study. One of the primary limitations present in this study is its descriptive and ecological nature, which limits the study to only allow for a description of the responses and possible reasons behind them at the group level. However, given the fact that a true experimental study did not seem appropriate for the goals of this research this limitation's importance is negligible. In order to reproduce the conditions for the survey the use of a short, telephone oriented procedure was utilized, but by doing so it limited the answers of the participants to brief responses without much leeway for expounding upon tangential thoughts. Furthermore, the Likert scale utilized in the survey was small (1 to 5/strongly disagree-strongly agree) and this relatively small answer range may have prevented more specificity of results by choosing not to use to use a 7 or 10 choice scale instead. However, given the fact that the survey was conducted via telephone it might have been exceedingly difficult for respondents to visualize their answer on a larger scale. The ambiguous phrasing of some of the questions, while intended from the outset of the survey, also may have caused respondents to interpret the questions in different ways resulting in their answers following a different path.

While this study had limitations it also provided avenues for future research. This study served to provide a general assessment of bed bug infestations throughout the state of Ohio while also determining what trends there were in the beliefs of local public health officials in charge of nuisance complaint oversight. Given more time, future research could attempt to gather comprehensive data pertaining to the true prevalence and incidence throughout Ohio by not only providing health departments with adequate time to gather information but also contacting private pest control applicators as well as the state fire marshal in order to procure numbers

pertaining to lodging establishments such as hotels. Furthermore, future research could look into possible policy changes that would allow for the ability of local public health departments to take a more active role in infestation mitigation. Lastly, in order to discern the true extent of outbreaks future studies could contact various states to determine whether or not bed bugs are a problem in their area, and, if so, what do they have in their power to do to control infestations?

Conclusion

Bed bug outbreaks continue to be a re-emerging problem in the United States and abroad (Eddy & Jones, 2011). Bed bug infestations have been found to not only cause potentially debilitating medical consequences for their victims but have recently been shown to have the ability to severely impact the mental health of those affected (Rossi, 2010). As a result people who have been exposed to bed bug infestations have been known to report a greatly reduced quality of life (Rossi, 2010). In attempting to remedy infestations some individuals have sometimes turned to improper treatment options to rid their lives of this nuisance, and have ended up exposing themselves and their loved ones to potentially hazardous environmental stressors, which has made the issue of bed bug infestations one that goes beyond the scope of the bug's ability to transmit disease. Among 79 public health professionals throughout Ohio there is a general consensus that the non-infectious disease implications of bed bug infestations are a public health concern, however, health departments in general do not possess the means to address outbreaks in a proactive manner but instead must rely on informing affected individuals about what they can do to treat their property. In order to reduce the burden caused by bed bugs throughout Ohio and the nation as a whole it is apparent that non-infectious disease concerns should be considered and information should be dispersed to the public detailing the non-infectious disease concerns associated with infestations. If successful, possible media

campaigns, when coupled with IPM strategies, may lead individuals to take greater precaution when engaging in behaviors that may lead to bed bug infestations, and as a result, this pest will be limited in its capacity to be a detriment to the public's health.

Acknowledgements

I would like to acknowledge and extend my thanks and gratitude to the following people who have helped in the completion of my culminating experience: The Chair of my Guidance Committee, Mr. Christopher Eddy, for his guidance and motivating me to think outside the box and approach the bed bug issue with an open mind. Dr. Michelle Colledge, for her technical expertise and advice for improving the quality of my paper. Mrs. Sylvia Ellison, for her statistical knowledge and ability to help me organize my data more clearly. I would also like to thank the faculty and instructors of the Wright State University Public Health Program broadening my academic horizons and instilling me with principles and values that will help make me into a successful public health practitioner in the future. Lastly, I'd like to thank all of the public health officials who responded to my survey. Thanks to your generous contribution I feel like I was able to take a step in the direction of assessing where we stand with outbreaks throughout the state and it makes me proud to know that men and women do really care about the health and well being of the public that they serve.

References

(2009). *Pesticides: Reregistration- Pesticide Reregistration Status for Organophosphates.* Retrieved from: http://www.epa.gov/pesticides/reregistration/status_op.htm.

(2010). *Joint Statement on Bed Bug Control in the United States from the U.S. Centers for Disease Control and Prevention (CDC) and the U.S. Environmental Protection Agency (EPA).* Retrieved from: http://www.cdc.gov/nceh/ehs/Publications/Bed_Bugs_CDC-EPA_Statement.htm.

Berg, R. (2010). Bed Bugs: The Pesticide Dilemma. *Journal of Environmental Health, 72*(10), 32-35.

Delaunay, P., Blanc, V., Del Guidice, V., Levy-Bencheton, A., Chosidow, O., Marty, P., & Brouqui, P. (2011). Bedbugs and Infectious Diseases. *Clinical Infectious Diseases, 52*(2), 200-210. Retrieved from: http://cid.oxfordjournals.org/content/52/2/200.full.pdf+html.

Doggett, S., & Russell, R. (2009). Bed bugs- What the GP needs to know. *Australian Family Physician, 38*(11), 880-884.

Eddy, C. & Jones, S. (2011). Bed Bugs, Public Health, and Social Justice. *Journal of Environmental Health, 73*(8): 8-17.

Fairchild, A.L., Rosner, D., Colgrove, J., Bayer, R., & Linda, P. (2010). The EXODUS of Public Health: What History Can Tell Us About the Future. *American Journal of Public Health. 100*(1): 54-63.

Fishel, F.M. (2008). *Pesticide Toxicity Profile: Organophosphate Pesticides*. Retrieved from: http://edis.ifas.ufl.edu/pi087.

Geist-May, K. (2011). *Tenant tries to kill bed bugs, starts fire.* Retrieved from: http://cincinnati.com/blogs/considerthisclermont/2011/01/24/tenant-tries-to-kill-bed-bugs-starts-fire/.

Goddard, J. (2009). Bed Bugs (Cimex lectularius) and Clinical Consequences of Their Bites. *Journal of the American Medical Association*, *301*(13), 1358-1366.

Hildreth, C.J., Burke, A.E., & Glass, R.M. (2009). Bed Bugs. *The Journal of the American Medical Association*, *301*(13), 1398.

Hurst, S & Humphreys, M. (2011). Bedbugs: Not Back by Popular Demand. *Dimensions of Critical Care Nursing*, *30*(2), 94-96, doi: 10.1097/DCC.0b13e318205214f.

Hwang, S.A., Svoboda, T.J., De Jong, I.J., Kabasele, K.J., & Gogosis, E. (2005). Bed Bug Infestations in an Urban Environment. *Emerging Infectious Diseases*, *11*(4), 533-538. Retrieved from: http://www.cdc.gov/ncidod/eid/vol11no04/pdfs/04-1126.pdf.

Joelving, F. (2009, May 17). ADHD in kids tied to organophosphate pesticides. *Reuters*. Retrieved from: http://www.reuters.com/assets/print?aid=USTRE64G41R20100517.

Kells, S. (2006a). Bed Bugs: A Systemic Pest within Society. *American Entomologist*, *52*(2), 107-108.

Kells, S. (2006b). Nonchemical Control of Bed Bugs. *American Entomologist*, *52*(2), 109-110.

Koehler, P. (2008). Ability of Bed Bug-Detecting Canines to Locate Live Bed Bugs and Viable Bed Bug Eggs. *Journal of Economic Entomology*, *101*(4), 1389-1396.

Koehler, P. (2009). Lethal Effects of Heat and Use of Localized Heat Treatment for Control of Bed Bug Infestations. *Journal of Economic Entomology*, *102*(3), 1182-1188.

Kolb, A., Needham ,G.R., Neyman, K.M., & High, W.A. (2009). Bedbugs. *Dermatologic Therapy*, *22*(4), 347-352.

Krause-Parello, C.A., & Sciscione, P. (2009). Bedbugs: An Equal Opportunist and Cosmopolitan Creature. *The Journal of School Nursing*, *25*(2), 126-132.

Krieger, J. (2002). Housing and health: time again for public health action. *American Journal of Public Health*, *92*(5), 758-768

Kweka, EJ. (2009). Insecticides Susceptibility Status of the Bedbugs (Cimex lectularius) in a Rural Area of Magugu, Northern Tanzania. *Journal of Global Infectious Diseases*, *1*(2), 102-106.

Leingang, M. (2010). *Bedbug Infestations Spur Pesticide Misuse, EPA Seeking Solutions*. Retrieved from: http://www.chem.info/News/2010/08/Safety-Bedbug-Infestations-Spur-Pesticide-Misuse-EPA-Seeking-Solutions/.

Levy Bencheton, A., Berenger, J.M., Del Giudice, P., Delaunay, P., Pages, F., & Morand, J.J. (2010). Resurgence of bedbugs in southern France: a local problem or the tip of the iceberg? *Journal of the European Academy of Dermatology and Venereology*, doi: 10.1111/j.1468-3083.2010.03804.x.

Lowe, C.F. & Romney, M.G. (2011). Bedbugs as vectors for drug-resistant bacteria [letter]. *Emerging Infectious Disease*, *17*(6). Retrieved from: http://www.cdc.gov/EID/content/17/6/1132.htm.

Naylor, R.A., & Boase, J. (2010). Practical Solutions for Treating Laundry Infested with Cimex lectularius (Hemiptera: Cimicidae). *Journal of Economic Entomology*, *103*(1), 136-139.

Omudu, E.A., & Kuse, C.N. (2010). Bedbug infestation and its control practices in Gbajimba: a rural settlement in Benue state, Nigeria. *Journal of Vector Borne Disease, 47*(4), 222.227.

Periera, R.M., Koehler, P.G., Pfiester, M., & Walker, W. (2009). Lethal Effects of Heat and Use of Localized Heat Treatment for Control of Bed Bug Infestations. *Journal of Economic Entomology, 102*(3), 1182-1188.

Potter, M. (2009). Behavioral Responses of the Bed Bug to Insecticide Residues. *Journal of Medical Entomology, 46*(1), 51-57.

Pritchard, MJ. (2009). Cases: Severe anemia from bedbugs. *Canadian Medical Association Journal, 181*(5), 287-288.

Rauh, V.A., Landrigan, P.J., & Claudio, L. (2008). Housing and Health. *Annals of the New York Academy of Sciences, 1136*(1), 276-288.

Reinhardt, K., Harder, A., Holland, S., Hooper, J., & Leake-Lyall, C. (2008). Who Knows the Bed Bug? Knowledge of Adult Bed Bug Appearance Increases with People's Age in Three Counties of Great Britain. *Journal of Medical Entomology, 45*(5), 956-958.

Romero, A., Potter, M.F., Potter, D.A., & Haynes, K.F. (2007). Insecticide Resistance in the Bed Bug: A Factor in the Pest's Sudden Resurgence? *Journal of Medical Entomology, 44*(2), 175-178.

Romero, A., Potter, M.F. & Haynes, K.F. (2010). Evaluation of chlorfenapyr for control of the bed bug. *Cimex lectularius L. Pest Management Science*, doi: 10.1002/ps.2002.

Rossi, L. (2010). Bed Bugs: A Public Health Problem in Need of a Collaborative Solution. *Journal of Environmental Health, 72*(8), 34-35.

Ruel, E., Oakley, D., Wilson, E., & Maddox, R. (2010). Is Public Housing the Cause of Poor Health or a Safety Net for the Unhealthy Poor? *Journal of Urban Health*, doi: 10.1007/s11524-010-9484-y.

Appendix A - Sample Phone Interview Template

Hello,

My name is Christopher Balster and I am a graduate student in the Public Health program at Wright State University. I am currently working on my culminating experience project and would greatly appreciate if you would be willing to participate in a brief research survey at this time.

For my project, I am attempting to ascertain the capacity of local public health departments to respond to the relatively recent re-emergence of bed bug infestations throughout the state and the nation as a whole. I hope to gauge the prevalence of infestations throughout southwestern Ohio while also determining whether or not local public health departments possess the means to address outbreaks if they occur within in their jurisdiction.

The survey will be brief and should require no more than 10 minutes of your time. Your participation in answering these questions is completely voluntary. Your responses to all questions I ask will be kept anonymous, unless you choose otherwise. There are no known risks to this study, and participants will not receive any direct benefits for participating.

If you have any questions about the research, I can answer the questions now, or provide you with contact information for later use. If you have any questions about participating in research in general, I can also provide you with a Wright State contact.

Thank you for agreeing to participate!

Questions:

1.) Bed bug outbreaks are a public health concern. Yes or no?
2.) If you can recall, when was your first reported bed bug case? Can you estimate how many bed bug infestations there were in your jurisdiction in 2005? In 2010? Are there any specific populations more at risk for infestations than others?
3.) At this time the lack of an ability to serve as a disease vector makes bed bug outbreaks more of a nuisance than a public health concern. (likert scale)

    Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

4.) Non-infectious disease effects (improper pesticide applications, mental health concerns, etc.) of bed bug infestations are a public health concern? (likert scale)

    Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

5.) Do you believe that your department is adequately funded to manage bed bug complaints? Yes or No?
6.) Local health departments do not possess sufficient funds and/or resources to effectively combat bed bug infestations. (likert scale)

    Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

7.) One of the best ways to limit bed bug outbreaks is through educating the public about preventative measures. (likert scale)

    Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

8.) The creation of new, more effective pesticides is necessary to effectively limit and control bed bug infestations. (likert scale)

    Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

Appendix B

Public Health Competencies

My culminating experience allowed me to demonstrate numerous public health competencies. The construction of my literature review allowed me to clearly define the problem faced by local health departments in regard to bed bug, and other, pest infestations. As a result of the lack of housing programs and funding given to actively treat pest infestations health departments have to maximize their effectiveness while utilizing minimal resources. In order to clearly define the problem and gauge the situation throughout Ohio I gathered quantitative data from a majority of the departments in Ohio to come up with an idea of where most departments stand in regard to their ability to handle this re-emerging concern. While bed bugs are rising in prevalence the amount of documentation regarding their pervasiveness is relatively nonexistent and as a result this gap in information was something I attempted to gain a grasp on through my survey questions. Going through the IRB process allowed me to ensure that my data collection methods were ethically sound and did not infringe upon the rights of the participants' in any way. Once data collection was completed and analysis began I was able to infer that, while a majority of health departments view the non-infectious disease aspects of infestations to be a public health concern, the general lack of resources has prevented a majority of agencies from being able to actively remedy these concerns. Furthermore, analysis of the data has allowed me to discern which regions of Ohio are more apt to encounter more bed bug problems while also shedding light on which populations are more at risk of being affected than others. The fact that my data suggest that lower socioeconomic status individuals and renters are more likely to have issues with bed bugs than others illustrates how bed bug infestations may occur with people who lack the means to adequately handle the situation, and as such it raises the

ethical concerns about whether local public health is morally obligated to help rectify the issue. Also, the presence of instances in which landlords and pesticide applicators are misusing existing treatment techniques and thus placing tenants and others in potentially hazardous situations this topic becomes an important public health issue that has ramifications in the areas of science, politics, and economics in addition to ethical concerns.

An inherent component of conducting the applied research was the collection, summarization, and interpretation of information relevant to the bed bug issue. This information included the history of bed bugs, studies looking into how they affect human health, and also information relating to the capacity of public health departments to mitigate during a period of increased incidence and prevalence. By delving into information regarding the most up to date techniques for treatment of infestations it was also possible to incorporate aspects of IPM and preventative measures into recommendations for how to attempt to stymie the resurgence of bed bugs throughout Ohio. Furthermore, this pertinent information allowed for a thought process to occur that was used to decide upon the most feasible and appropriate course of action for local health departments in the form of attempting to continue to educate the public as much as possible and provide assistance when necessary.

The nature of the culminating experience makes the project one in which communication is key, not only in the gathering of information, but also in assimilating said information and then presenting it to both the committee and those interested in hearing what was found throughout the study. In order to accomplish what I sought to I had to collect data by soliciting input from numerous public health officials throughout the state. As a result of my attempt to gather information my resolve has been strengthened regarding this issue in that the non-infectious disease implications of bed bug infestations do present a danger in some instances and should

therefore not be overlooked by public health. In order to create my project I extensively combed media outlets in search of bed bug related news and information. In addition, the data collection process itself required the utilization of advanced technologies such as spreadsheet programs and survey creation techniques to effectively communicate with my participants in order to acquire relevant information. Lastly, by calling health departments in every area of Ohio I was able to generate a study reflecting the views of a diverse field of professionals, which allowed for the creation of accurate demographic and statistical measures that I was able to pass to audiences through this project.

Bed bug infestations have historically been shown to disproportionately affect those of a lower socioeconomic status. As such it was important to express to all participants that this study was conducted with the intention to determine the extent to which individuals are affected by bed bug related problems while making sure to remain sensitive to the effects that infestations can have on those affected by them. The results of my studies confirmed that those of a lower socioeconomic status or those who dwell in multi-unit housing tended to be more inclined to be affected by this problem compared to others and as a result my recommendations sought to adapt to this problem in a manner that would facilitate mitigation among these groups. However, in order to truly be able to understand and suggest what direction public health should take in mitigation efforts it was essential that I first look back on the history of public health and the progression of its mission over the years.

Public health started off dealing with the problem of improving the health of communities by limiting the transmission of infectious disease, but after success in that area and the development of different health concerns the focus of public health has shifted throughout the decades. It was important nonetheless to look back and acquire information regarding public

health's ability to intervene on behalf of the public. In order to perform my project I had to utilize a wide array of public health sciences and research methods. As mentioned before I implemented a telephone survey and created a sample population in order to gain a grasp of beliefs among Ohio's local public health agencies. Furthermore, my project contained concepts involving epidemiology, biostatistics, social sciences, environmental public health, and the prevention of chronic and infectious injuries and disease, thus allowing me to comprehensively assess the situation and determine what I believe to be a reasonable course of action. In order to successfully implement tenets of these public health sciences I had to identify and retrieve current scientific literature regarding the prevalence of bed bugs, the medical consequences of their infestations, and the potential hazards brought about by improper pesticide applications to allow me to weigh different variables when determining the severity of the issue. As a result, I was able to identify the limitations of my research and research in general while also stressing the importance of the observations and interrelationships present within a research project. The combination of all the competencies utilized in this study have created a strong foundation for future endeavors and will no doubt allow me to confidently pursue research ventures that adhere to and uphold the essential research traits desired in a piece of public health literature.

Appendix C

IRB Approval

Office of Research and Sponsored Programs
201J University Hall
3640 Col. Glenn Hwy.
Dayton, OH 45435-0001
(937) 775-2425
(937) 775-3781 (FAX)
e-mail: rsp@wright.edu

DATE: March 31, 2011

TO: Christopher Balster, PI, Grad. Student
Community Health
Christopher Eddy, MPH, Instructor

FROM: B. Laurel Elder, Ph.D., Chair
WSU Institutional Review Board

SUBJECT: SC# 4437
'Non-Infectious Disease Implications of Bed Bug Infestations'

This memo is to verify the receipt and acceptance of your response to the conditions placed on the above referenced human subjects protocol/amendment.

These conditions were lifted on: 03/31/2011

This study/amendment now has full approval and you are free to begin the research project. If this is a VA proposal, you must still receive a letter of approval from the Research and Development Committee prior to beginning the research project. This implies the following:

1. That this approval is for one year from the approval date shown on the Action Form and if it extends beyond this period a request for an extension is required. (Also see expiration date on the Action Form)

2. That a progress report must be submitted before an extension of the approved one-year period can be granted.

3. That any change in the protocol must be approved by the IRB; otherwise approval is terminated.

If you have any questions concerning the condition(s), please contact Jodi Blacklidge at 775-3974.

Thank you!
Enclosure

RESEARCH INVOLVING HUMAN SUBJECTS

SC# 4437

ACTION OF THE WRIGHT STATE
UNIVERSITY
EXPEDITED REVIEW
Assurance Number: FWA00002427

Title: *'Non-Infectious Disease Implications of Bed Bug Infestations'*

Principal Investigator: Christopher Balster, PI, Grad. Student
Christopher Eddy, MPH, Instructor

Department: Community Health

Expedited Category: 7

The Institutional Review Board has approved the use of human subjects on this proposed project with conditions previously noted. The conditions have now been removed.

REMINDER: FDA regulations require prompt reporting to the IRB of any changes in research activity, changes in approved research during the approval period may not be initiated without IRB review (submission of an amendment), and prompt reporting of any unanticipated problems (adverse events).

B Lenard Elder PhD

Signed Chair, WSU-IRB

Expedited Review Date: March 25, 2011

IRB Meeting Date: April 18, 2011

This approval is effective only through: ***March 24, 2012***
To continue the activities approved under this protocol you should receive the appropriate form(s) from Research and Sponsored Programs (RSP) two to three months prior to the required due date. If you do not receive this notification, please contact RSP at 775-2425.

Appendix D

Raw Data

Region	Q #1	Q #2a	Q #2b	Q #2c	Q #3	Q #4	Q #5	Q #6	Q #7	Q #8
NE	2	2009	0	out of towner question	1	3	2	5	4	4
NE	1		0	None	1	4	2	5	4	5
NE	1	2011	2	None	2	4	2	5	5	3
NE	1	2009	1	None	2	5	2	5	4	5
NE	1		0	None	3	4	1	5	5	3
NE	1		0	None	4	5	2	5	4	3
NE	1	2010	3	None	4	5	2	5	5	3
NE	1		0	None	2	4	2	2	4	3
NE	1	2001	6	None	1	4	1	5	5	5
NE	2	2010	7	Apartments	2	5	2	5	4	5
NE	1	2010	2	None	3	5	2	5	4	5
NE	1	1994	68	low income	3	5	2	5	5	1
NE	1	2010	1	no data	3	3	2	5	5	5
NE	1	2008	100	multi-unit housing	3	5	2	4	5	5
NE	1	2009	0	None	1	3	2	5	5	5
NE	1	2011			4	4	2	5	5	3
NE	1	2010	5	none	2	4	2	5	4	4
NE	1		0	none	1	3	2	3	5	3
NE	1	2006	5	hotel/motel	2	5	2	4	5	3
NW	1	2008	20	lower SES	2	4	1	5	4	5
NW	1	2010	10 to 15	No	2	2	2	4	3	4
NW	1	2010	6	rental	2	3	2	5	5	2
NW	1	2009	4	rental	2	5	2	5	4	4
NW	1	2007	7	multi-unit housing	2	5	2	5	4	3
NW	1	2011	0	No	2	5	2	4	5	2
NW	1	2010	3	No	3	3	2	4	4	4
NW	1	2010	12	apartments	1	5	2	5	5	5
NW	1	2008	17	low income	2	3	2	4	5	4
NW	2	2011	0	none	1	4	1	5	5	4
NW	1	2009	3	none	3	5	2	5	5	5
NW	1	2010	4	younger	3	5	2	5	4	3
NW	2	2010	12	rental	1	4	2	4	5	5
NW	1	2010	4	none	2	2	2	5	5	4
NW	1	2006	2	none	3	4	2	5	5	4
NW	2	2007	8	low income, motels	1	4	1	4	4	5
NW	1	2009	15 to 20	none	2	4	1	3	5	4
NW	1	2010	4	none	3	3	1	5	5	2

NW	1	2009	5	hotel	3	4	1	4	5	5
NW	1	2011	0	none	4	1	1	5	5	1
NW	1	2010	3	none	3	4	1	4	4	3
NW	2	2009	2	none	1	5	1	3	5	2
NW	2	2010	1	none	1	3	2	4	3	5
SE	1	2008	75	none	4	4	2	5	5	5
SE	1.5	2010	1	none	2	2	2	4	4	5
SE	1	2008	10+	lower SES	2	4	2	5	3	3
SE	1	2006	4	none	2	4	2	5	5	5
SE	1	2008	6 to 10	none	1	1	2	5	5	
SE	1	2009	12	none	1	5	2	5	2	5
SE	1	2009	25 to 30	none	1	5	1	5	5	5
SE	1	2009	0	none	2	4	2	5	4	5
SE	1		0	none	3	4	2	5	5	4
SE	1	2009	5	none	1	4	1	5	5	4
SE	1	2009	10	none	2	4	1	5	5	2
SE	1	2011	0	none	3	4	2	4	4	5
SE	2	2006	0	none	1	3	1	5	4	2
SE	1	2011	0	none	3	5	2	5	5	3
SE	1	2010	2	none	4	5	2	4	5	3
SE	1	2009	30	lower SES	2	5	2	5	5	2
SE	1	2010	0	none	1	3	2	5	3	5
SE	2	2009	10	lower SES	1	5	2	5	5	5
SE	1	2008	12	rental, lower ses	3	5	2	5	5	2
SW	1	2006	241	lower SES	3	4	2	5	5	5
SW	2	2009	30	lower SES	2	4	2	5	4	4
SW	1	2010	4	sporadic	3	2	1	5	5	5
SW	2	2006	40	sporadic	1	3	2	5	5	5
SW	1	2010	300+	lower SES	2	3	2	4	5	4
SW	1	2010	10	none	2	4	1	4	2	5
SW	1	2010	30	multi-unit housing, lower SES	1	5	1	4	5	5
SW	2	2007	20	None	1	1	2	5	5	3
SW	1	2010	20 to 25	multi-units and single units	2	4	2	5	5	5
SW	1	2010	2	None	1	3	2	4	3	5
SW	1	2002	300	renters, lower SES	5	5	1	5	5	5
SW	1	2009	0	B	3	4	2	5	3	5
SW	2	2007	1-2/day	None	1	3	2	5	3	5
SW	1	2008	300	Rental	4	5	2	5	5	5
SW	2	2007	177	lower SES	1	5	2	5	5	5
SW	1	2010	25	None	2	3	2	4	4	5
SW	2	2007	181	None	1	2	2	5	5	4
SW	1	2007	100+	lower SES	2	5	2	4	5	4